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Liu

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(54) **POWER CONVERSION SYSTEM**

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H02J 3/32 (2006.01)
H02J 3/38 (2006.01)
H02J 7/00 (2006.01)

(52) **U.S. Cl.**

CPC ***H02J 3/32*** (2013.01); ***H02J 3/381*** (2013.01); ***H02J 7/0063*** (2013.01); *H02J 2300/24* (2020.01)

(58) **Field of Classification Search**

CPC .. H02J 3/32; H02J 3/381; H02J 7/0063; H02J 2300/24
See application file for complete search history.

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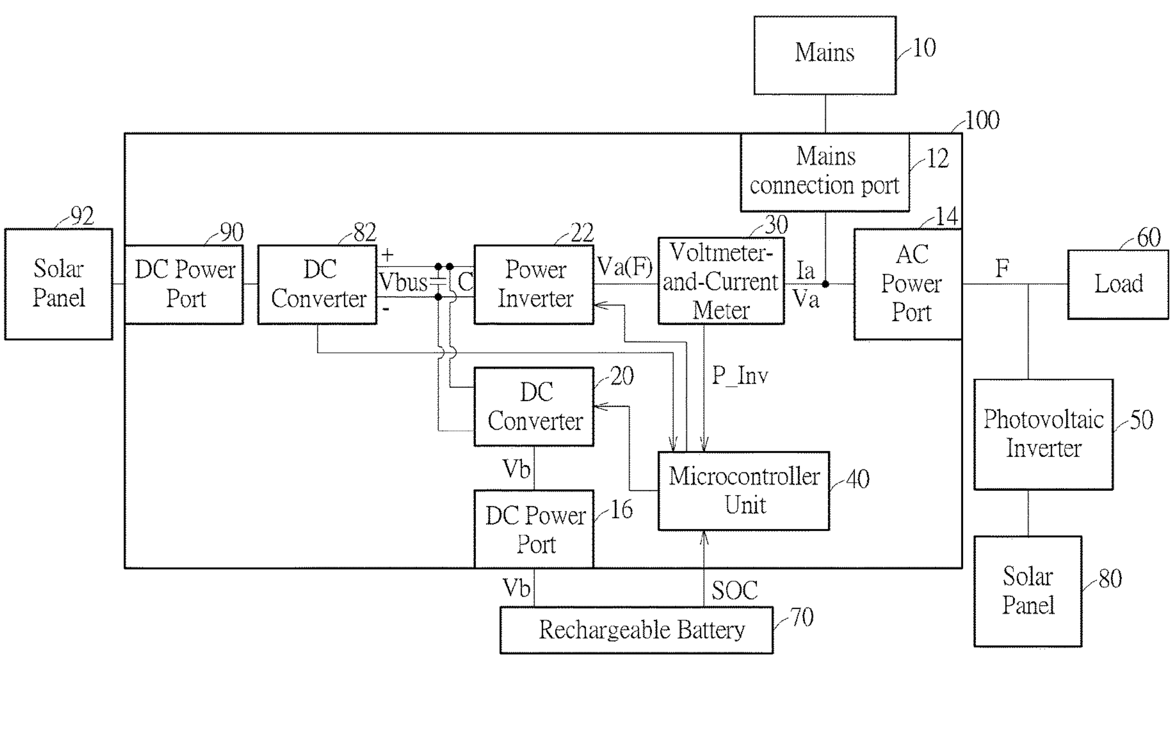
(57) **ABSTRACT**

A power conversion system (PCS) includes an alternating current (AC) power port, a first direct current (DC) power port, a second DC power port, a high voltage capacitor, a first DC converter, a second DC converter, a power inverter, and a microcontroller unit. The microcontroller unit adjusts a frequency of an AC power output by the power conversion system based on a voltage difference across the high voltage capacitor of the power conversion system to switch the frequency of the AC power between different frequencies.

9 Claims, 7 Drawing Sheets



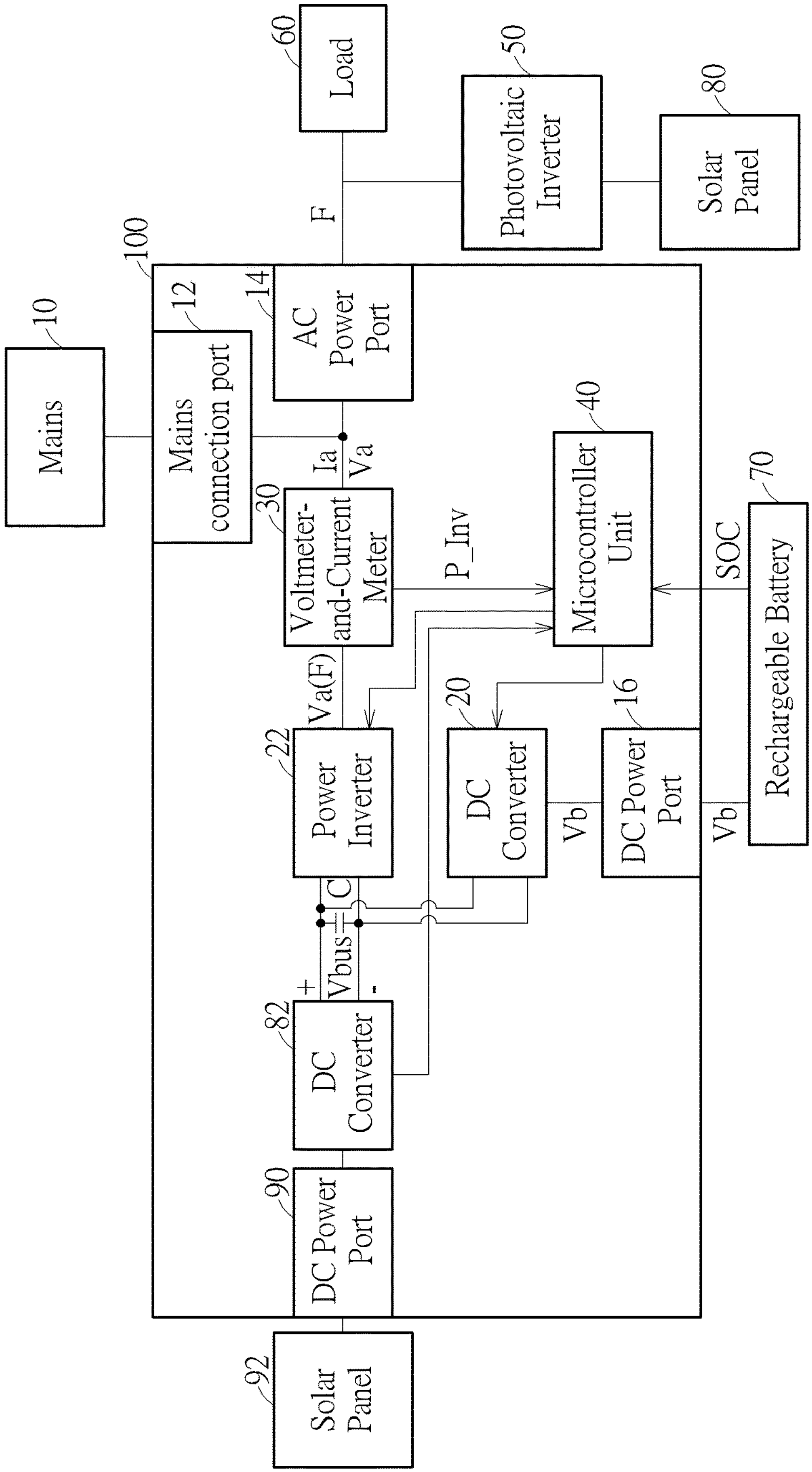

Load
60
Photovoltaic Inverter
50
Solar Panel
80
F
100
Mains
10
Mains connection port
12
AC Power Port
14
Ia
Va
Voltmeter-and-Current Meter
30
P_Inv
Microcontroller Unit
40
SOC
Rechargeable Battery
70
Va(F)
Power Inverter
22
DC Converter
20
Vb
DC Power Port
16
Vb
C
Vbus
+
-
DC Converter
82
DC Power Port
90
Solar Panel
92

FIG. 1

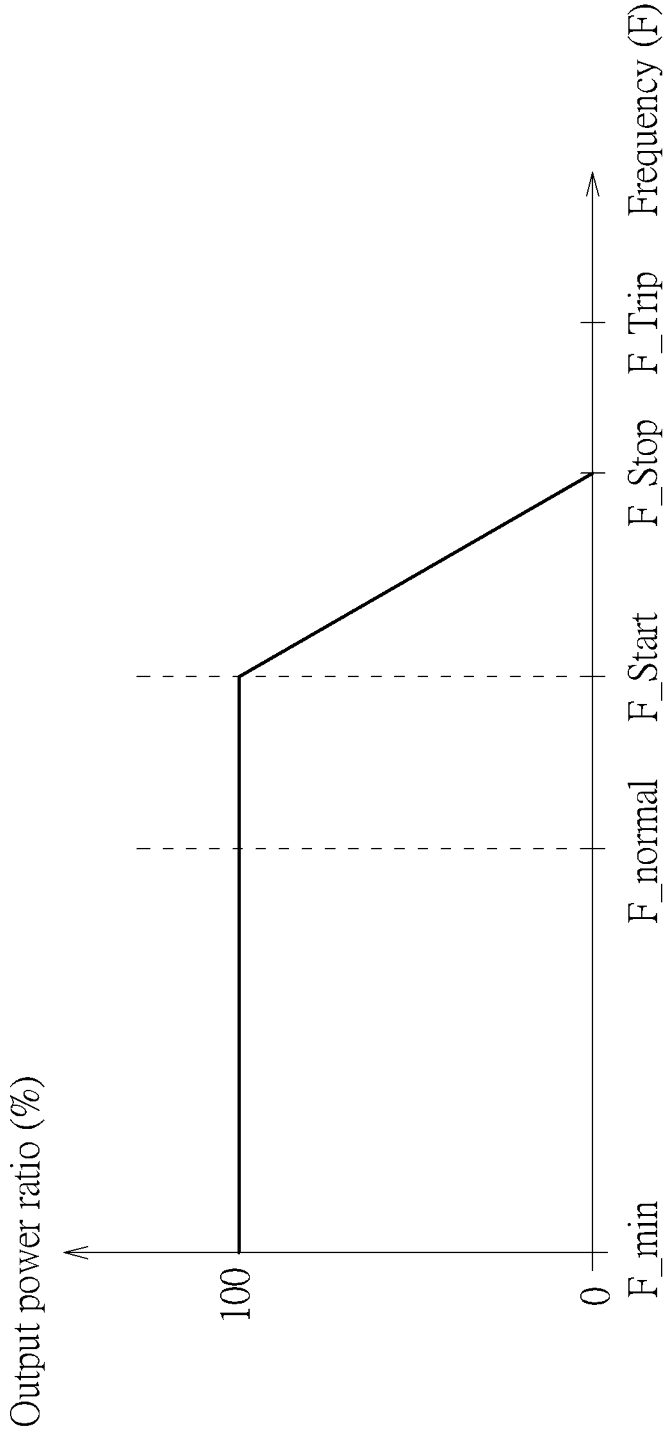

Output power ratio (%)
100
0
F_min
F_normal
F_Start
F_Stop
F_Trip
Frequency (F)

FIG. 2

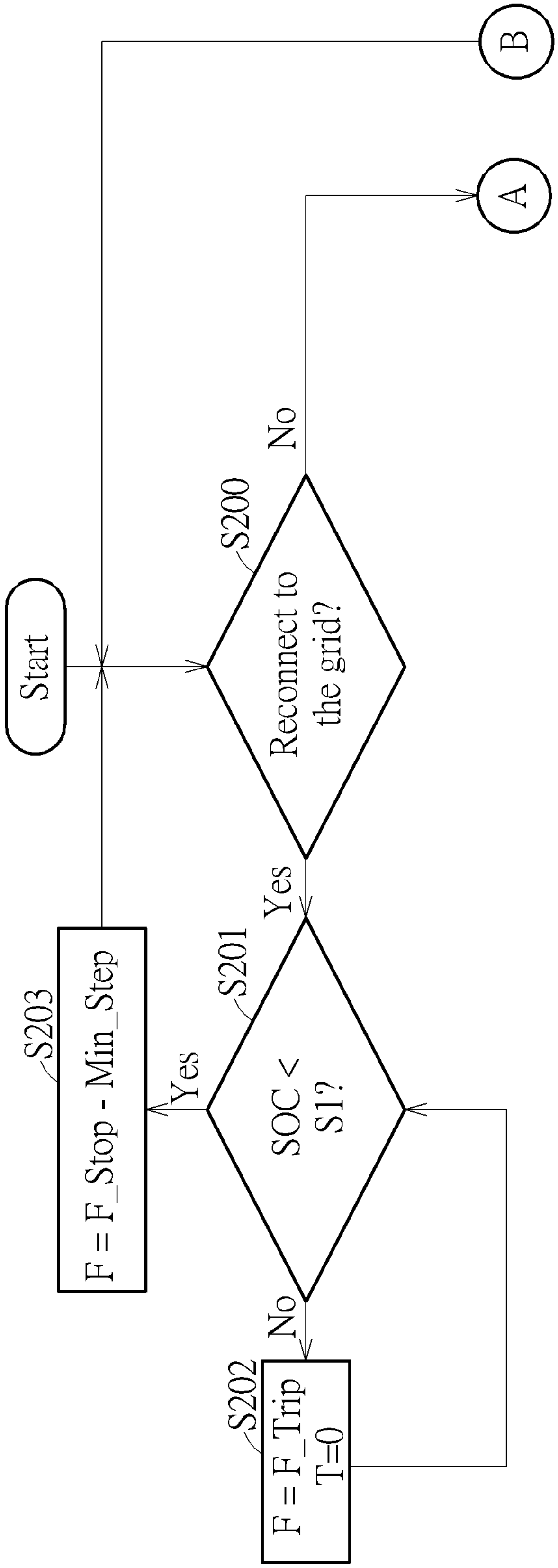

Start
Reconnect to the grid?
S200
No
A
B
Yes
SOC < S1?
S201
Yes
F = F_Stop - Min_Step
S203
No
F = F_Trip
T=0
S202

FIG. 3A

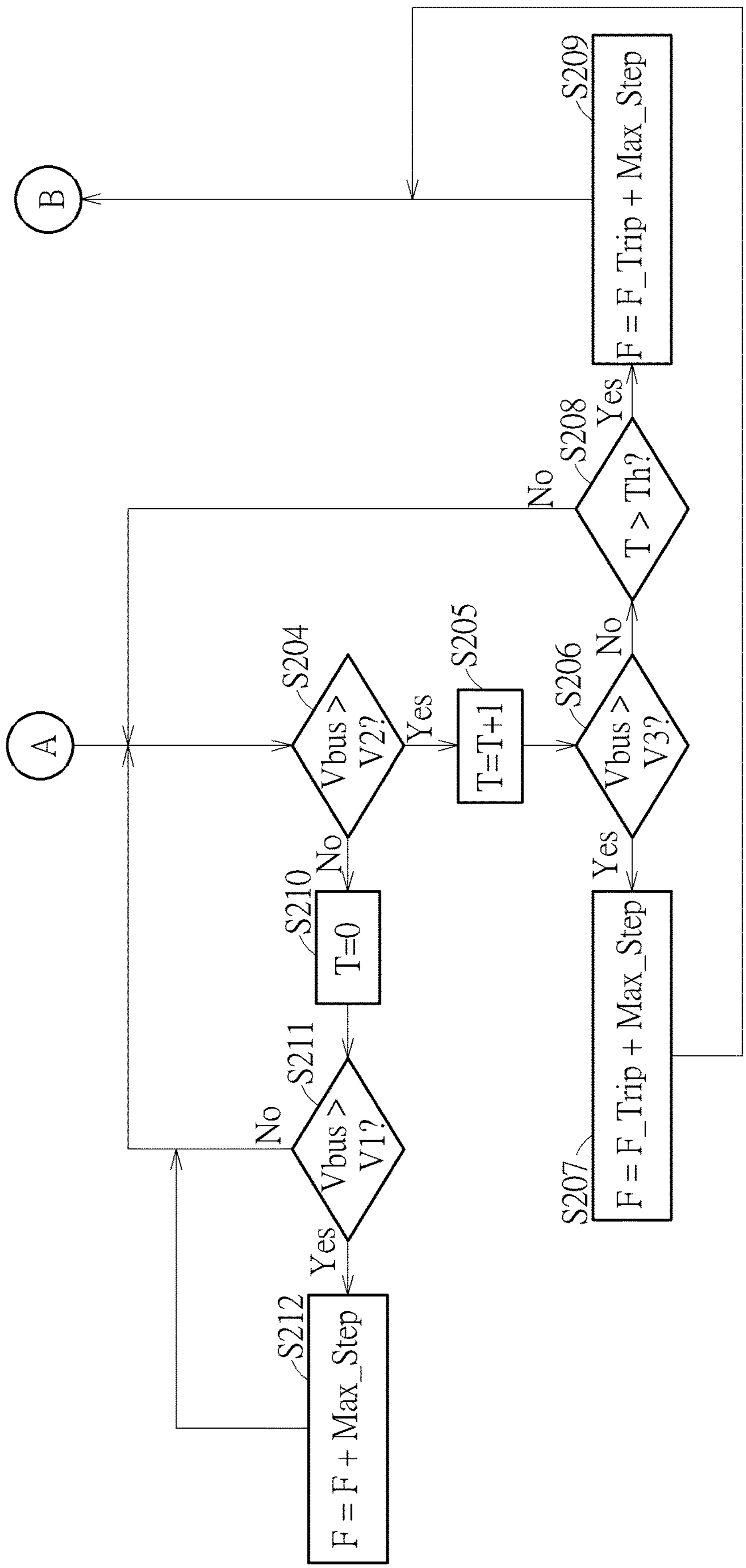

A
B
S204
Vbus > V2?
Yes
No
S205
T=T+1
S206
Vbus > V3?
Yes
No
S207
F = F_Trip + Max_Step
S208
T > Th?
Yes
No
S209
F = F_Trip + Max_Step
S210
T=0
S211
Vbus > V1?
Yes
No
S212
F = F + Max_Step

FIG. 3B

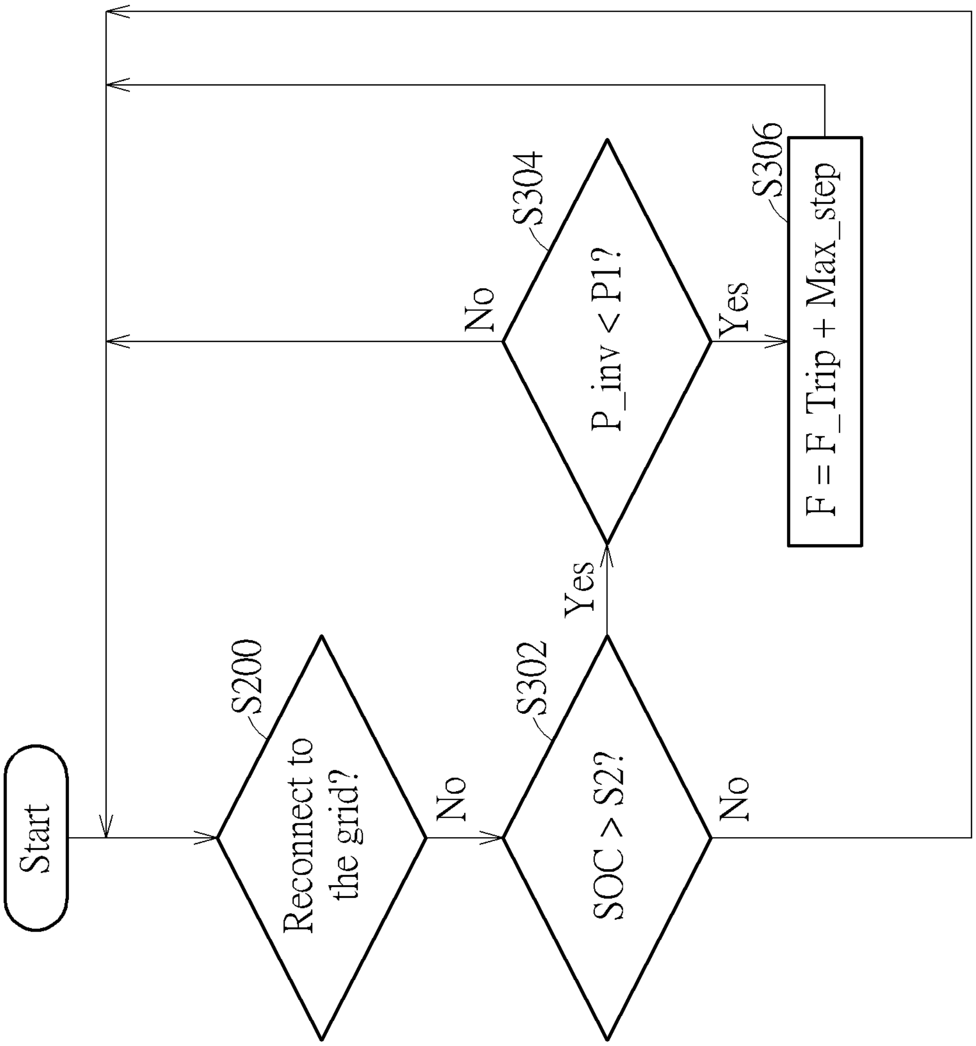

Start
S200
Reconnect to the grid?
No
S302
SOC > S2?
Yes
No
S304
P_inv < P1?
No
Yes
S306
F = F_Trip + Max_step

FIG. 4

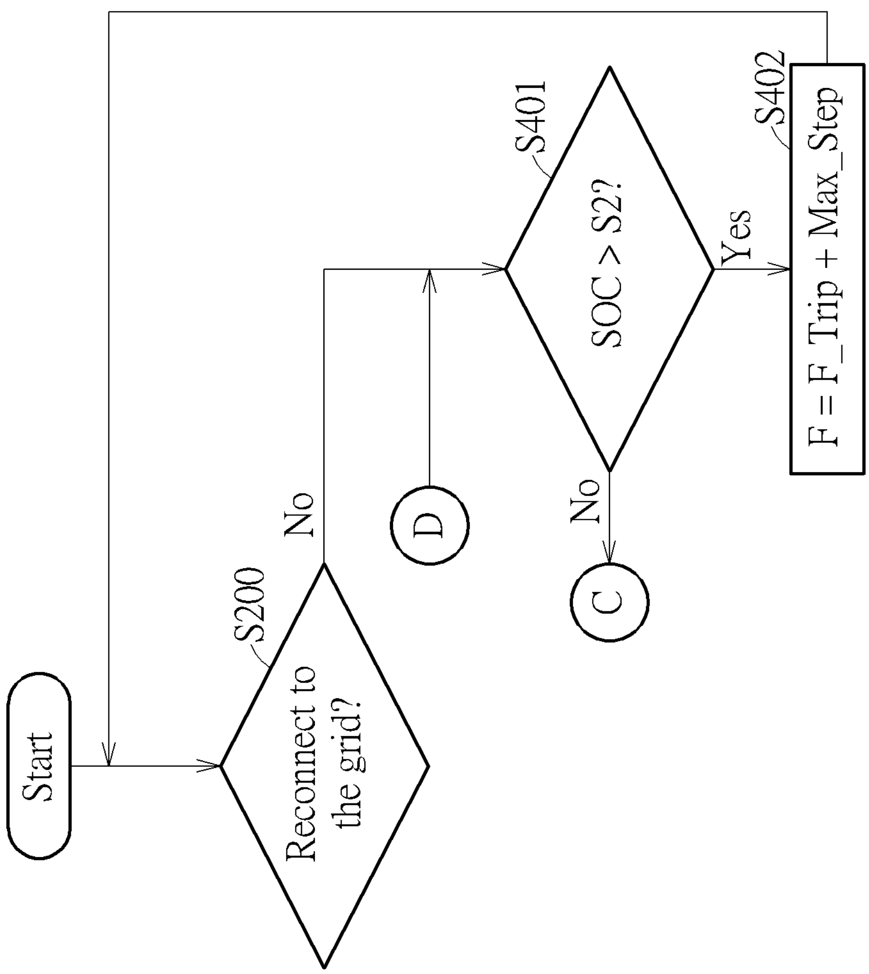

Start
Reconnect to the grid?
S200
No
D
S401
SOC > S2?
Yes
No
C
S402
F = F_Trip + Max_Step

FIG. 5A

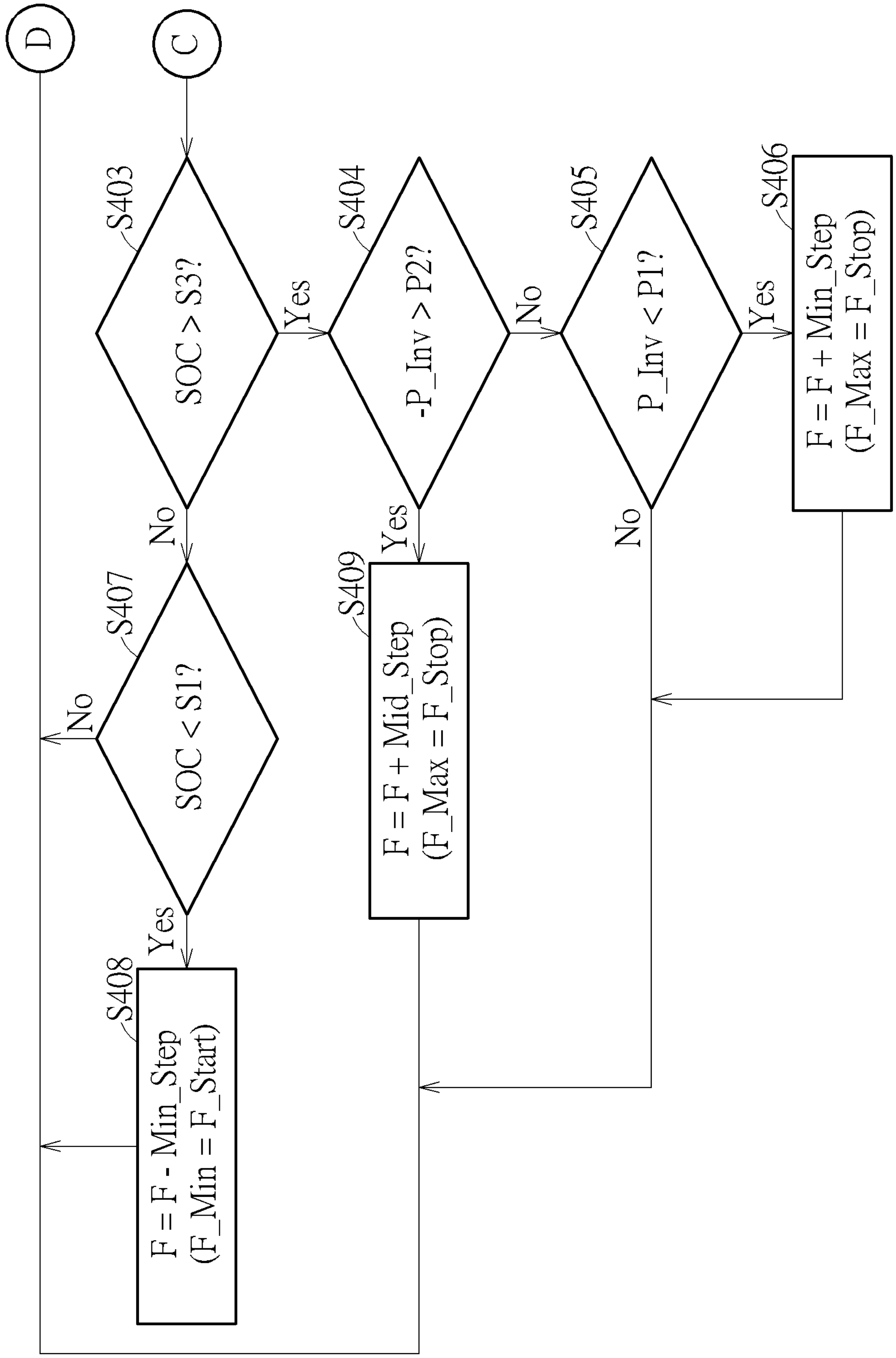

C
D
S403
SOC > S3?
Yes
No
S404
-P_Inv > P2?
No
Yes
S405
P_Inv < P1?
Yes
No
S406
F = F + Min_Step
(F_Max = F_Stop)
S407
SOC < S1?
No
Yes
S408
F = F - Min_Step
(F_Min = F_Start)
S409
F = F + Mid_Step
(F_Max = F_Stop)

FIG. 5B

POWER CONVERSION SYSTEM

CROSS REFERENCE TO RELATED APPLICATION

This application claims the benefit of U.S. Provisional Application No. 63/328,267, filed on Apr. 6, 2022. The content of the application is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention is related to a power conversion system (PCS), in particular to a power conversion system that can adjust the output AC frequency according to the charged ratio of a rechargeable battery.

2. Description of the Prior Art

Power conversion system (PCS) is a bidirectional power conversion inverter that can be used for on-grid and off-grid electrical power storage applications. The efficient operation of a power conversion system has always been an important issue in this technical field.

SUMMARY OF THE INVENTION

A power conversion system of the present invention comprises an alternating current power port, a first direct current power port, a second direct current power port, a high voltage capacitor, a first DC converter, a second DC converter, a DC/AC inverter, a microcontroller unit. The alternating current power port is coupled to a photovoltaic inverter. The first direct current power port is coupled to a rechargeable battery. The second direct current power port is coupled to a solar panel. The first DC converter is coupled between the high voltage capacitor and the first DC power port. The second DC converter is coupled between the high voltage capacitor and the second DC power port. The DC/AC inverter is coupled between the high voltage capacitor and the AC power port. The microcontroller unit is for adjusting the frequency of an AC output from the AC power port by the power conversion system according to the voltage difference between two ends of the high voltage capacitor. When the microcontroller unit detects mains off-grid and the voltage difference is greater than a first critical value, the microcontroller unit sets a frequency of the AC output from the AC power port as a cut-off frequency, so that the photovoltaic inverter stops outputting power. When the microcontroller unit detects mains off-grid and the voltage difference is between the first critical value and a second critical value for a continuous time exceeding a predetermined time length, the microcontroller unit sets the frequency of the AC output from the AC power port as the cut-off frequency. When the microcontroller unit detects mains off-grid and the voltage difference is between the second critical value and a third critical value, the microcontroller unit increases the frequency of the AC output from the AC power port by a first predetermined value. The first critical value is greater than the second critical value, and the second critical value is greater than the third critical value.

These and other objectives of the present invention will no doubt become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiment that is illustrated in the various figures and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a functional block diagram of a power conversion system according to an embodiment of the present invention and the coupled mains, load, rechargeable battery, photovoltaic inverter, and solar panel.

FIG. **2** is a relationship diagram between the output power ratio of the photovoltaic inverter in FIG. **1** and the frequency of the alternating current output by the power conversion system.

FIG. **3**A and FIG. **3**B are flowcharts of the microcontroller unit in FIG. **1** controlling the power conversion system.

FIG. **4** is another flow chart of the microcontroller unit in FIG. **1** controlling the power conversion system.

FIG. **5**A and FIG. **5**B are another flowchart of the microcontroller unit of FIG. **1** controlling the power conversion system.

DETAILED DESCRIPTION

FIG. **1** is a functional block diagram of a power conversion system (PCS) according to an embodiment of the present invention and the coupled mains **10**, a load **60**, a rechargeable battery **70**, a photovoltaic inverter (PV inverter) **50**, a solar panel **80** and a solar panel **92**. The solar panel **80** and the solar panel **92** are used to convert light into power. The PV inverter **50** converts the direct current power generated by the solar panel **80** to alternating current power, and feeds the converted alternating current into the load **60** and/or the power conversion system **100**.

The power conversion system **100** includes a mains connection port **12**, an AC power port **14**, a DC power port **16**, a high voltage capacitor C, a DC converter **20**, a power inverter **22**, a voltmeter-and-current meter **30**, a DC converter **82**, a DC power port **90** and a microcontroller unit (MCU) **40**. The power conversion system **100** can be connected to the mains **10** through the mains connection port **12** and receive power from the mains **10**. The DC power port **16** is coupled to the rechargeable battery **7**, and the power conversion system **100** can charge the rechargeable battery **70** through the DC power port **16** or receive power from the rechargeable battery **70**. The voltmeter-and-current meter **30** is coupled to the AC power port **14** to detect the voltage Va and current Ia output from the AC power port **14** by the power conversion system **100**, wherein the voltage Va and the current Ia are the AC voltage and the AC current respectively. The MCU **40** controls the operation of the power conversion system and receives a state-of-charge signal SOC from the rechargeable battery **70**. Wherein, the MCU **40** can obtain the current charged ratio of the rechargeable battery **70** according to the state-of-charge signal SOC, and obtain the output power P_Inv of the power conversion system **100** according to the voltage Va and current Ia detected by the voltmeter-and-current meter **30**. Wherein, when the output power P_Inv is positive, it means that the power conversion system **100** outputs power through the AC power port **14**; and when the output power P_Inv is negative, it means that the power conversion system **100** receives power from the outside through the AC power port **14**. The DC converter **20** is coupled between the high voltage capacitor C and the DC power port **16** for converting the DC voltage Vb output by the rechargeable battery **70** into a voltage difference Vbus between two ends of the high voltage capacitor C. The DC converter **82** is coupled between the high voltage capacitor C and the DC power port **90** for converting the DC voltage output by the solar panel **92** into a voltage difference Vbus between the two ends of the high voltage capacitor C. Therefore, the size of the voltage difference Vbus is determined by the DC voltage Vb and the DC voltage output by the solar panel **92**. The power inverter **22** is coupled between the high voltage capacitor C and the AC power port **14** for converting the voltage difference Vbus into an AC voltage Va, and the frequency of the AC voltage Va is F.

Please refer to FIG. **2**. FIG. **2** is a relationship diagram between the output power ratio of the photovoltaic inverter **50** in FIG. **1** and the frequency F of the alternating current output by the power conversion system **100**. The horizontal axis of FIG. **2** represents the frequency F of the AC power output by the power conversion system **100** from the AC power port **14**, and the vertical axis of FIG. **2** represents the output power ratio of the photovoltaic inverter **50**. The position marked **100** on the vertical axis in FIG. **2** indicates that the output of the photovoltaic inverter **50** is at the maximum value (i.e. 100%), and the position marked 0 on the vertical axis indicates that the output of the photovoltaic inverter **50** is stopped. Furthermore, when the frequency F is between F_Start and F_Stop, the output power ratio and the frequency F have a linear inverse relationship, that is, the larger the output power ratio at this time, the lower the AC frequency F will be. Wherein F_min<F_normal<F_Start<F_Stop, and F_min represents the minimum value of the frequency F of the alternating current output by the power conversion system **100**, and F_normal is the frequency of the power conversion system **100** in general normal operation. The output power ratio corresponding to F_Start is equal to 100%, and the output power ratio corresponding to F_Stop is equal to 0%. Wherein, F_min may be referred to as "minimum frequency", F_normal may be referred to as "normal frequency", F_Start may be referred to as "start frequency", and F_Stop may be referred to as "stop frequency". The start frequency F_Start is, for example, 60 Hertz (Hz), and the stop frequency F_Stop is, for example, 60.5 Hz. Furthermore, there is another cut-off frequency F_trip, which forces the photovoltaic inverter **50** to stop outputting power, so that the power conversion system **100** enters into over-frequency protection (F_Trip is, for example, 60.6 Hz. Since the photovoltaic inverter **50** stops outputting power once the frequency F of the alternating current exceeds F_Trip, the frequency F_trip may be referred to as the "cut-off frequency").

The DC converter **82** can detect the voltage difference Vbus between the two ends of the high voltage capacitor C, and transmit the data of the voltage difference Vbus to the microcontroller unit **40**, so that the microcontroller unit **40** adjusts the frequency F according to the voltage difference Vbus to control the output power of the photovoltaic inverter **50**. Furthermore, when the microcontroller unit **40** detects that the mains off-grid (for example: when the connection between the connection port **12** and the mains **10** is cut off or the mains **10** is powered off), the microcontroller unit **40** can adjust the frequency F according to the voltage difference Vbus, and then adjust the output power of the photovoltaic inverter **50**. For example, the normal value of the voltage difference Vbus is 400 to 430 volts, and when the voltage difference Vbus exceeds 450 volts, it means that the high-voltage capacitor C has accumulated too much energy. Therefore, at this time, the microcontroller unit **40** will first turn off the solar panel **92**, and then turn off the photovoltaic inverter **50**. Furthermore, if the voltage difference Vbus is less than 450 volts but greater than 430 volts, the frequency F is increased so that the photovoltaic inverter **50** reduces its output power.

Please refer to FIG. **3**A and FIG. **3**B, FIG. **3**A and FIG. **3**B are flowcharts of the control of the power conversion system **100** by the microcontroller unit **40** of FIG. **1**. When the microcontroller unit **40** detects that the mains off-grid (for example: when the connection between the connection port **12** and the mains **10** is cut off or the mains **10** is powered off) or reconnected and feeding to the grid, the microcontroller unit **40** executes the process of FIG. **3**A and FIG. **3**B, and this process includes the following steps:

Step S**200**: the microcontroller unit **40** determines whether the power conversion system **100** is reconnected to the grid, wherein when the conversion system **100** is reconnected to the mains **10** or the photovoltaic inverter **50** starts to supply power; it means that the power conversion system **100** is reconnected to the grid. When the microcontroller unit **40** determines that the power conversion system **100** has been reconnected to the grid, execute step S**201**; otherwise, execute step S**204**;

Step S**201**: the microcontroller unit **40** determines whether the current charged ratio of the rechargeable battery **70** is less than a predetermined ratio S**1** according to the state-of-charge signal SOC, wherein the predetermined ratio S**1** may between 10% and 80%, if the microcontroller unit **40** determines that the current charged ratio of the rechargeable battery **70** is not less than the predetermined ratio S**1**, then execute step S**202**; otherwise, execute step S**203**;

Step S**202**: the microcontroller unit **40** resets the accumulated time T of its timer to zero (T=0), and the frequency F of the alternating current output by the power conversion system **100** from the alternating current power supply port **14** is set as the cut-off frequency F_trip, so that the photovoltaic inverter **50** stops outputting power, and the power conversion system **100** enters the over-frequency protection; return to step S**201**;

Step S**203**: the microcontroller unit **40** lowers the frequency F from the stop frequency F_Stop by a predetermined value Min_Step (i.e. F=F_Stop−Min_Step), so that the photovoltaic inverter **50** can output power, and return to step S**200**. The predetermined value Min_Step can be equal to ((F_Stop−F_Start)/8);

Step S**204**: the microcontroller unit **40** determines whether the voltage difference Vbus between the two ends of the high voltage capacitor C is greater than the critical value V**2**. Wherein, the critical value V**2** can be, for example, 445 volts to 455 volts; if the microcontroller unit **40** determines that the voltage difference Vbus is greater than the critical value V**2**, then execute step S**205**; otherwise, execute step S**210**;

Step S**205**: the timer in the microcontroller unit **40** adds 1 to its accumulated time;

Step S**206**: the microcontroller unit **40** determines whether the voltage difference Vbus between the two ends of the high voltage capacitor C is greater than the critical value V**3**. Wherein, the critical value V**3** can be 465 volts to 475 volts; if the microcontroller unit **40** determines that the voltage difference Vbus is greater than the critical value V**3**, then execute step S**207**; otherwise, execute step S**208**;

Step S**207**: the microcontroller unit **40** increases the frequency F to (F_Trip+Max_step), so that the photovoltaic inverter **50** coupled to the AC power port **14** stops outputting power, and enters the over-frequency protection. Wherein, Max_step is, for example, 0.3 Hz or equal to ((F_Stop−F_Start)/2). Furthermore, once the frequency F of the alternating current reaches above F_Trip, the photovoltaic inverter **50** stops outputting power, therefore, when the frequency F of the alternating current is equal to (F_Trip+Max_step), it is more guaranteed that the photovoltaic inverter **50** stops outputting power; return to step S**200**;

Step S**208**: the microcontroller unit **40** determines whether the accumulated time T of the timer is greater than the predetermined time length Th. The predetermined time length Th can be, for example, 5 seconds, and when the microcontroller unit **40** determines that the accumulated time T of its timer is greater than the predetermined time length Th, then execute step S**209**; otherwise, return to step S**204**;

Step S**209**: the microcontroller unit **40** increases the frequency F to (F_Trip+Max_step), so that the photovoltaic inverter **50** coupled to the AC power port **14** stops outputting power, and enters the over-frequency protection. After the microcontroller unit **40** executes step S**209**, return to step S**200**;

Step S**210**: the microcontroller unit **40** resets the accumulated time T of its timer to zero (T=0);

Step S**211**: the microcontroller unit **40** determines whether the voltage difference Vbus between the two ends of the high voltage capacitor C is greater than the critical value V**1**. Wherein, the critical value V**1** can be 425 volts to 435 volts; if the microcontroller unit **40** determines that the voltage difference Vbus is greater than the critical value V**1**, then execute step S**212**; otherwise, execute step S**204**; and

Step S**212**: the microcontroller unit **40** increases the frequency F by Max_step, that is, F=(F+Max_step), so that the photovoltaic inverter **50** reduces the output power; return to step S**204**.

When the photovoltaic inverter **50** detects that the voltage or frequency exceeds the normal operating range, it starts protection (for example: overvoltage, under voltage, over frequency, under frequency, islanding . . . etc.), and then no longer outputs power and feeds to the grid, at this time, the microcontroller unit **40** determines whether the photovoltaic inverter **50** has tripped, and adjusts the AC output frequency F of the power conversion system **100** according to the state to determine whether the photovoltaic inverter **50** can be reconnected and fed to the grid. If the photovoltaic inverter **50** detects that the voltage and frequency of the mains terminal meet the normal operating range, it determines that the condition for reconnecting to the grid is met, and the photovoltaic inverter **50** counts a certain number of seconds (for example: 300 seconds as specified by grid-connected regulations) and will be fed into the grid output.

In another embodiment of the present invention, in addition to executing the flow in FIG. **3**A and FIG. **3**B according to the voltage difference Vbus, the microcontroller unit **40** will also execute the flow in FIG. **4** according to the current charged ratio of the rechargeable battery **70**. The flow chart in FIG. **4** includes the following steps:

Step S**200**: this step is the same as step S**200** in FIG. **3**A, that is, the microcontroller unit **40** determines whether the power conversion system **100** is reconnected to the grid. When the microcontroller unit **40** determines that the power conversion system **100** is reconnected to the network, execute step S**201** in FIG. **3**A; otherwise, execute step S**302**;

Step S**302**: the microcontroller unit **40** determines whether the current charged ratio of the rechargeable battery **70** is greater than a predetermined ratio S**2** according to the state of charge signal SOC, wherein the predetermined ratio S**2** is, for example, between 20% and 90%, and when the microcontroller unit **40** determines that the current charged ratio of the rechargeable battery **70** is greater than the predetermined ratio S**2**, execute step S**304**; otherwise, execute step S**200**;

Step S**304**: the microcontroller unit **40** determines whether the output power P_Inv is less than the predetermined power P**1**, wherein the predetermined power P**1** (for example, 500 watts), and can be adjusted according to different control requirements. When the microcontroller unit **40** determines that the output power P_Inv is less than the predetermined power P**1**, execute step S**306**; otherwise, return to step S**200**; and

Step S**306**: the microcontroller unit **40** increases the frequency F of the alternating current output by the power conversion system **100** from the alternating current power supply port **14**, so that the photovoltaic inverter **50** coupled to the alternating current power supply port **14** stops outputting power and enters the over-frequency protection. For example: the microcontroller unit **40** increases the frequency F of the alternating current to (F_Trip+Max_step). Wherein, F_Trip is, for example, 60.6 Hz, and Max_step is, for example, 0.3 Hz. Furthermore, once the frequency F of the alternating current reaches above F_Trip, the photovoltaic inverter **50** stops outputting power and the frequency F_trip may be referred to as a cut-off frequency. Therefore, when the frequency F of the alternating current is equal to (F_Trip+Max_step), it is more guaranteed that the photovoltaic inverter **50** stops outputting power; when the microcontroller unit **40** completes step S**306**, return to step S**200**.

In another embodiment of the present invention, in addition to executing the flow in FIG. **3**A and FIG. **3**B according to the voltage difference Vbus, the microcontroller unit **40** will also execute the flow in FIG. **5**A and FIG. **5**B according to the current charged ratio of the rechargeable battery **70**. The flow in FIG. **5**A and FIG. **5**B includes the following steps:

Step S**200**: this step is the same as step S**200** in FIG. **3**A, that is, the microcontroller unit **40** determines whether the power conversion system **100** is reconnected to the grid. When the microcontroller unit **40** determines that the power conversion system **100** is reconnected to the network, execute step S**201** in FIG. **3**A; otherwise, execute step S**401**;

Step S**401**: the microcontroller unit **40** determines whether the current charged ratio of the rechargeable battery **70** is greater than a predetermined ratio S**2** according to the state of charge signal SOC, wherein the predetermined ratio S**2** may between 20% and 90%, and when the microcontroller unit **40** determines that the current charged ratio of the rechargeable battery **70** is greater than the predetermined ratio S**2**, execute step S**402**; otherwise, execute step S**403**;

Step S**402**: the microcontroller unit **40** increases the frequency F of the alternating current output by the power conversion system **100** from the alternating current power supply port **14** to (F_Trip+Max_Step), so that the photovoltaic inverter **50** coupled to the alternating current power supply port **14** stops outputting power and enters the over-frequency protection. Wherein, F_Trip is, for example, 62 Hz, and Max_step is, for example, 0.3 Hz. Furthermore, once the frequency F of the alternating current reaches above F_Trip, the photovoltaic inverter **50** stops outputting power and the frequency F_Trip may be may be referred to as a "cutoff frequency". Therefore, when the frequency F of the alternating current is equal to (F_Trip+Max_step), it is more guaranteed that the photovoltaic inverter **50** stops outputting power. Furthermore, Max_Step can be equal to ((F_Stop−F_Start)/2), and F_Trip is greater than F_Stop. When the microcontroller unit **40** finishes executing step S**402**, return to step S**200**;

Step S**403**: the microcontroller unit **40** determines whether the current charged ratio of the rechargeable battery **70** is greater than the predetermined ratio S**3** according to the state of charge signal SOC. Wherein, the predetermined ratio S**3** is smaller than the predetermined ratio S**2**, and can range from 15% to 85%. When the microcontroller unit **40** determines that the current charged ratio of the rechargeable battery **70** is greater than the predetermined ratio S**3**, execute step S**404**; otherwise, execute step S**407**;

Step S**404**: the microcontroller unit **40** determines whether the negative value of the output power P_Inv (i.e. −P_Inv) is greater than the predetermined power P**2**. Wherein, when the negative value of the output power P_Inv is positive, it means that the power conversion system **100** receives power from the outside, and the predetermined power P**2** is, for example, 1000 watts, but not limited thereto. When the microcontroller unit **40** does not determine that the negative value of the output power P_Inv is greater than the predetermined power P**2**, execute step S**405**; and when the microcontroller unit **40** determines that the negative value of the output power P_Inv is greater than the predetermined power P**2**, execute Step S**409**;

Step S**405**: the microcontroller unit **40** determines whether the output power P_Inv is less than the predetermined power P**1**. Wherein, the predetermined power P**1** is smaller than the predetermined power P**2**, and the predetermined power P**1** is, for example, 500 watts, but not limited thereto. When it is determined that the output power P_Inv is less than the predetermined power P**1**, execute step S**406**; otherwise, return to step S**401**;

Step S**406**: the microcontroller unit **40** increases the frequency F by a predetermined value Min_Step (i.e. F=F+Min_Step), and return to step S**401**. Wherein, the predetermined value Min_Step may be equal to ((F_Stop−F_Start)/8), and the frequency F is adjusted up to F_Stop in this step, that is, the maximum value F_Max of the frequency F in this step is F_Stop. The function of step S**406** is: when the current charged ratio of the rechargeable battery **70** is greater than the predetermined ratio S**3**, and the output power P_Inv is lower than the predetermined power P**1**, the output power of the photovoltaic inverter **50** is reduced by increasing the frequency F;

Step S**407**: the microcontroller unit **40** determines whether the current charged ratio of the rechargeable battery **70** is less than the predetermined ratio S**1** according to the state of charge signal SOC. Wherein the predetermined ratio S**1** is smaller than the predetermined ratios S**2** and S**3**, and can be between 10% and 80%. When the microcontroller unit **40** determines that the current charged ratio of the rechargeable battery **70** is smaller than the predetermined ratio S**1**, execute step S**408**; otherwise, return to step S**401**;

Step S**408**: the microcontroller unit **40** lowers the frequency F by a predetermined value Min_Step (i.e. F=F−Min_Step), and return to step S**401**. Wherein the frequency F is adjusted minimum to F_Start in this step, that is, the minimum value F_Min of the frequency F in this step is F_Start. The function of step S**408** is: when the current charged ratio of the rechargeable battery **70** is less than the predetermined ratio S**1**, the output power of the photovoltaic inverter **50** is increased by lowering the frequency F; and

Step S**409**: the microcontroller unit **40** raises the frequency F by a predetermined value Mid_Step (i.e. F=F+Mid_Step), and return to step S**401**. Wherein the predetermined value Mid_Step can be equal to ((F_Stop−F_Start)/4), and the frequency F is adjusted up to F_Stop in this step, that is, the maximum value F_Max of frequency F in this step is F_Stop. The function of step S**409** is: when the current charged ratio of the rechargeable battery **70** is greater than the predetermined ratio S**3**, and the power received by the power conversion system **100** from the outside is greater than the predetermined power P**2**, by increasing the frequency F, the output power of the photovoltaic inverter **50** is reduced.

When the microcontroller unit **40** of the present invention detects mains off-grid, it allows the power conversion system **100** to output the AC frequency F, then induce the photovoltaic inverter **50** not to enter the Islanding protection and can generate power and feed the grid, its energy can be supplied to the load **60** and the power conversion system **100**. The microcontroller unit **40** can dynamically adjust the frequency of the alternating current output by the power conversion system **100** according to the voltage difference Vbus between the two ends of the high voltage capacitor C, the current charged ratio of the rechargeable battery **70**, and the positive or negative magnitude of the output power P_Inv. Therefore, the overall power flow of the power conversion system **100** can be efficiently regulated.

Those skilled in the art will readily observe that numerous modifications and alterations of the device and method may be made while retaining the teachings of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.

DESCRIPTION OF REFERENCE NUMERALS

10: Mains
12: Mains connection port
14: AC Power Port
16, **90**: DC Power Port
20, **82**: DC Converter
22: Power Inverter
30: Voltmeter-and-Current Meter
40: Microcontroller Unit
50: Photovoltaic Inverter
60: Load
70: Rechargeable Battery
80, **92**: Solar Panel
100: Power Conversion System
C: High Voltage Capacitor
F: Frequency
F_min: Minimum Frequency
F_normal: Normal Frequency
F_Start: Start Frequency
F_Stop: Stop Frequency
F_Trip: Cut-off Frequency
Ia: Current
P_Inv: Output Power
Va: Voltage
Vb: DC Voltage
Vbus: Voltage Difference
SOC: State-of-Charge Signal
S**200** to S**212**, S**302** to S**306**, S**401** to S**409**: Steps

What is claimed is:

1. A power conversion system (PCS) comprising:

an alternating current (AC) power port coupled to a photovoltaic inverter;

a first direct current (DC) power port coupled to a rechargeable battery;
a second direct current (DC) power port coupled to a solar panel;
a high voltage capacitor;
a first DC converter coupled between the high voltage capacitor and the first DC power port;
a second DC converter coupled between the high voltage capacitor and the second DC power port;
a DC/AC inverter coupled between the high voltage capacitor and the AC power port; and
a microcontroller unit (MCU) for adjusting a frequency of an AC output from the AC power port by the power conversion system according to a voltage difference between two ends of the high voltage capacitor;
wherein when the microcontroller unit detects mains off-grid, and the voltage difference is greater than a first critical value, the microcontroller unit sets the frequency of the AC output from the AC power port as a cut-off frequency, so that the photovoltaic inverter stops outputting power;
wherein when the microcontroller unit detects mains off-grid, and the voltage difference is between the first critical value and a second critical value for a continuous time exceeding a predetermined time length, the microcontroller unit sets the frequency of the AC output from the AC power port as the cut-off frequency;
wherein when the microcontroller unit detects mains off-grid, and the voltage difference is between the second critical value and a third critical value, the microcontroller unit increases the frequency of the AC output from the AC power port by a first predetermined value; and
wherein the first critical value is greater than the second critical value, and the second critical value is greater than the third critical value.

2. The power conversion system of claim **1**, wherein the first critical value is 465 volts to 475 volts, the second critical value is 445 volts to 455 volts, and the third critical value is 425 volts to 435 volts.

3. The power conversion system of claim **1**, wherein when the microcontroller unit detects mains off-grid and a current charged ratio of the rechargeable battery is greater than a first predetermined ratio, and an output power of the power conversion system is lower than a first predetermined power, the microcontroller unit increases the frequency of the AC, so that the photovoltaic inverter stops outputting power.

4. The power conversion system of claim **3**, wherein when the microcontroller unit detects mains off-grid and determined that the current charged ratio of the rechargeable battery is greater than the first predetermined ratio and the output power is less than the first predetermined power, and when the voltage difference is smaller than the first critical value, the power conversion system supplies the power from the rechargeable battery to a load.

5. The power conversion system of claim **1**, wherein when the microcontroller unit detects mains off-grid, and determined that a current charged ratio of the rechargeable battery is greater than a first predetermined ratio, the microcontroller unit adjusts the frequency of the AC to a first frequency, so that the photovoltaic inverter stops outputting power.

6. The power conversion system of claim **5**, wherein when the microcontroller unit detects mains off-grid, and determined that the current charged ratio of the rechargeable battery is less than the first predetermined ratio and greater than a second predetermined ratio, and a negative value of an output power of the power conversion system is greater than the first predetermined power, the microcontroller unit increases the frequency of the AC output from the AC power port by the first predetermined value.

7. The power conversion system of claim **6**, wherein when the microcontroller unit detects mains off-grid, and determined that the current charged ratio of the rechargeable battery is less than a third predetermined ratio, the frequency of the AC output from the AC power port is lowered by a second predetermined value.

8. The power conversion system of claim **7**, wherein when the microcontroller unit detects mains off-grid, and determined that the current charged ratio of the rechargeable battery is less than the first predetermined ratio and greater than the second predetermined ratio, and the negative value of the output power is not greater than the first predetermined power, and the output power is less than a second predetermined power, the microcontroller unit increases the frequency of the AC output from the AC power port by a third predetermined value.

9. The power conversion system of claim **8**, wherein the second predetermined value is equal to the third predetermined value.

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